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# Wave-Particle Interactions and Particle Acceleration in Turbulent Plasmas: Hybrid Simulations

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Wave-particle interactions and acceleration processes are present in all key regions inside and outside of the heliosphere. Spacecraft observations measure ion distributions and accelerated ion populations, which are the result of one or several processes. For instance STEREO measures energetic particles associated with interplanetary discontinuities and in the solar wind. Voyager and IBEX provide unique data of energetic particles from the termination shock and the inner and outer heliopause. The range of plasma conditions covered by observations is enormous. However, the physical processes causing particle acceleration and wave-particle interaction and determining the particle distributions are still unknown. Currently two mechanisms, the so-called pumping mechanism (Fisk and Gloeckler, 2010) and merging/contracting island (Fermo, Drake & Swisdak, 2010) are discussed as promising models.
In order to determine these individual processes, numerical models or theoretical considerations are needed. Hybrid simulations, which include all kinetic processes self-consistently on the ion level, are a very proven, powerful tool to investigate wave-particle interaction, turbulence, and phase-space evolution of pickup and solar wind ions. In the framework of this study we performed 3D multi-species hybrid simulations for an ion/ion beam instability to study the temporal evolution of ion distributions, their stability, and the influence of self-generated waves. We investigated the energization of ions downstream of interplanetary discontinuities and shocks and downstream of the termination shock, the turbulence, and growth rate of instabilities and compared the results with theoretical predictions. The simulations show that ions can be accelerated downstream of collisionless shocks by trapping of charged particles in coherent wave fronts.